ATD-2
Integrated Arrival/Departure/Surface

NASA

Initial Data Analysis Results for ATD-2 ISAS HITL Simulation

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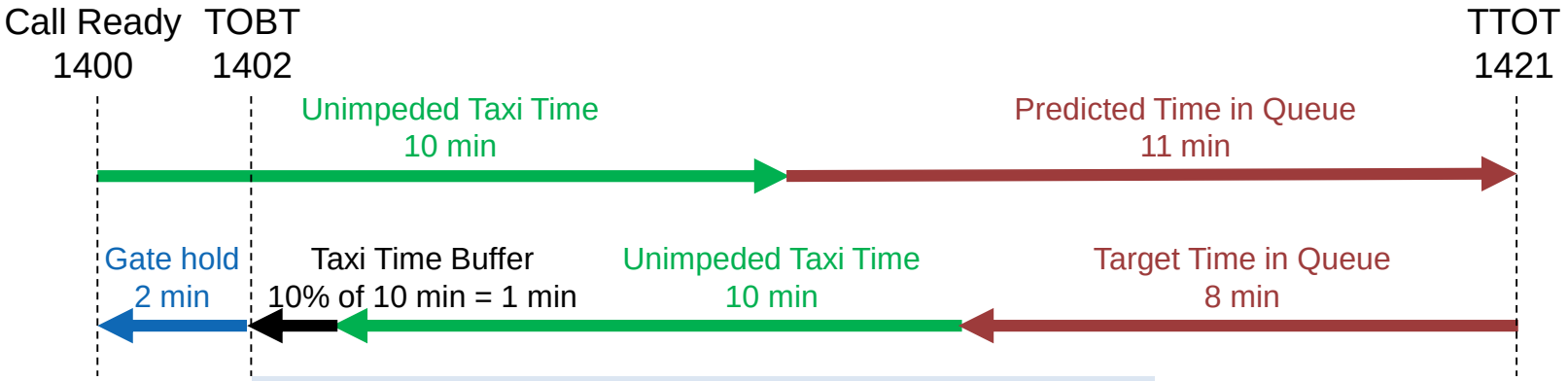
ATD-2 ISAS HITL Simulation

- Objectives
  - To evaluate operational procedures and information requirements for
    - **Tactical Surface Metering Tool**
    - APREQ procedures between ATC Tower and Center
    - Data exchange elements between Ramp and ATC Tower
- Scenarios
  - IFR rules in clear weather at Charlotte airport (CLT)
  - No GA / cargo flights
  - TMI flights included: APREQ/CFR, EDCTs, and MIT
  - North flow: 68 departures and 85 arrivals, with 3 turnaround
  - South flow: 63 departures and 89 arrivals, with 4 turnaround

Tactical Surface Metering Tool

- Provides pushback advisories to ramp controllers
- Departure demand control
  - Absorb delay in AMA and Ramp area by adding buffers in computing pushback time (TOBT)
    - Prevent runway over-saturation or starvation
    - Prevent too much or too little gate hold
  - Implement tunable parameters to maintain pressure on runway queue depending on demand/capacity



TOBT = max (EOBT, TTOT – X * taxi time – Y)

X: Taxi time buffer (e.g., X=1.1)
Y: Metering buffer (e.g., Y=8min)

Note) TOBT: Target Off-Block Time, EOBT: Earliest Off-Block Time, TTOT: Target Take-Off Time

HITL Simulation Runs

- Total eight runs having different runway configuration, metering buffer value, and MIT constraint conditions
  - Different durations, leading to different numbers of flights

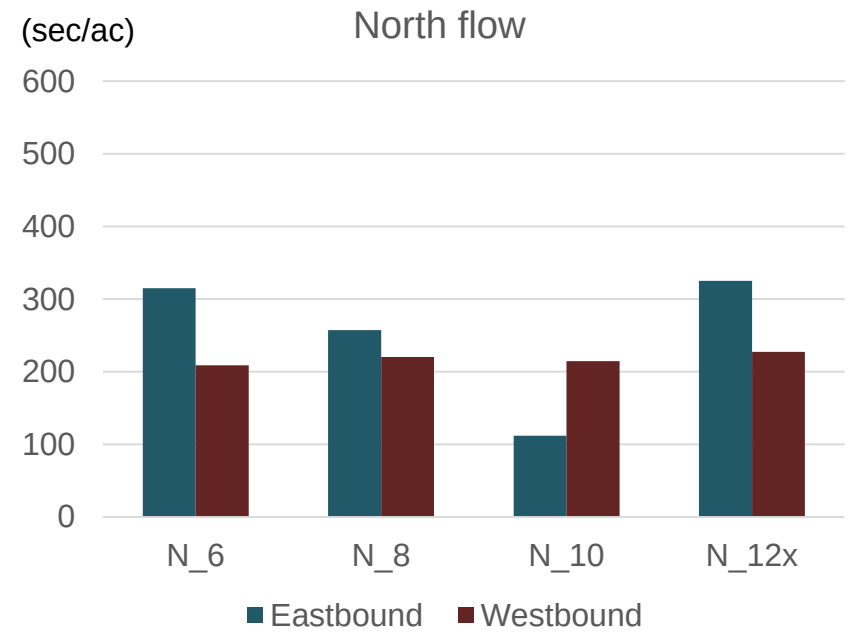
Run Name	Runway Configuration	Metering Value (min)	MIT Restriction	Duration (sec)	Dep No (OFF)	Arr No (IN)
N_6	North flow	More hold 6	Yes	3536	35	34
N_8		8	Yes	3979	44	38
N_10		10	Yes	3014	27	26
N_12x		Less hold 12	No	4034	54	50
S_8	South flow	More hold 8	Yes	3204	42	28
S_10		10	Yes	3145	41	34
S_12		12	Yes	3332	49	39
S_12x		Less hold 12	No	3380	49	43

Performance Metrics

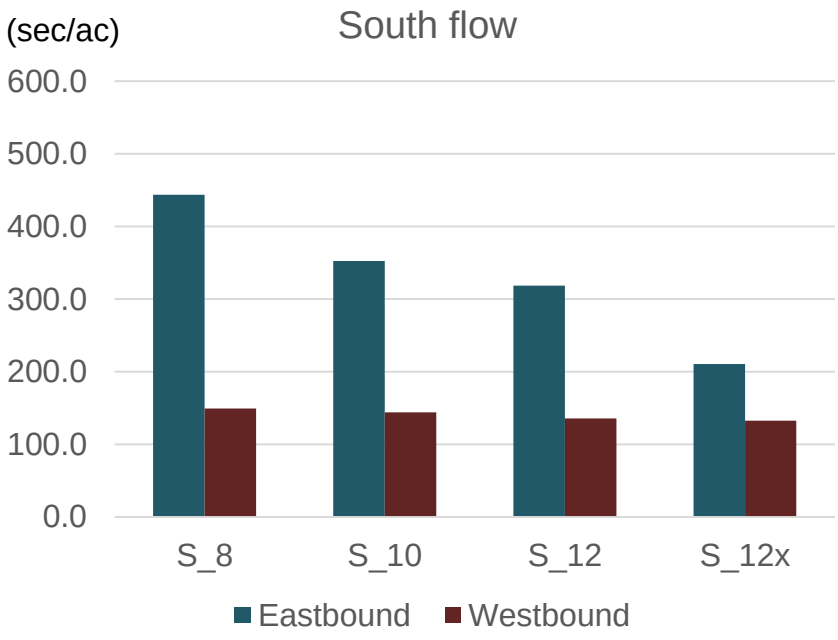
- Gate hold time
- Taxi times
  - Ramp area and AMA
  - Eastbound and Westbound
- Runway throughput
  - Accumulated takeoffs
- Surface congestion
  - Number of departures in AMA and ramp area
  - Departure queue length and average queue time
- Traffic Management Initiatives (TMI)
  - APREQ and EDCT flights

Gate Hold Time

- Mean gate hold times by runway
  - Based on the given EOBT times and actual out times
  - All departures taken off, including TMI flights
  - More holding with the lower metering value for Eastbound



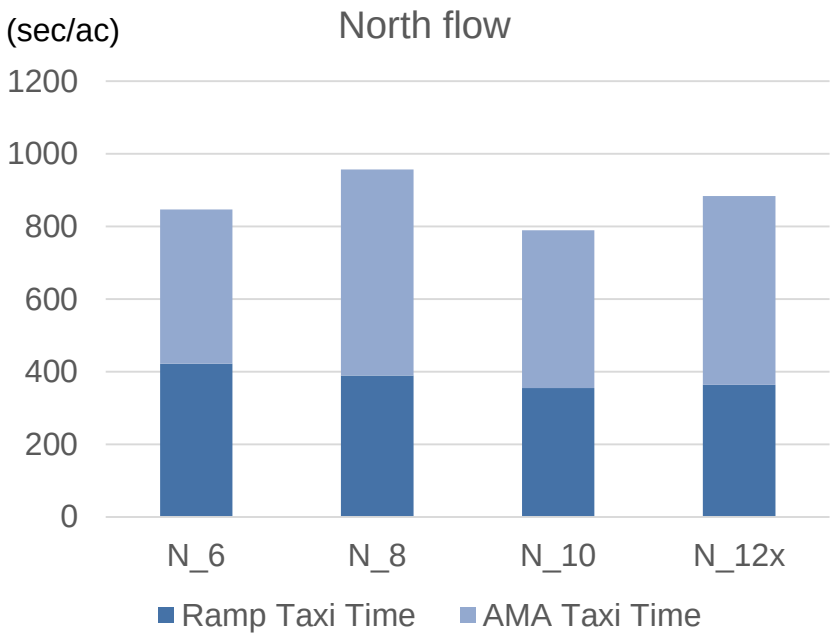
Dep No	15 | 20	17 | 27	14 | 13	20 | 34



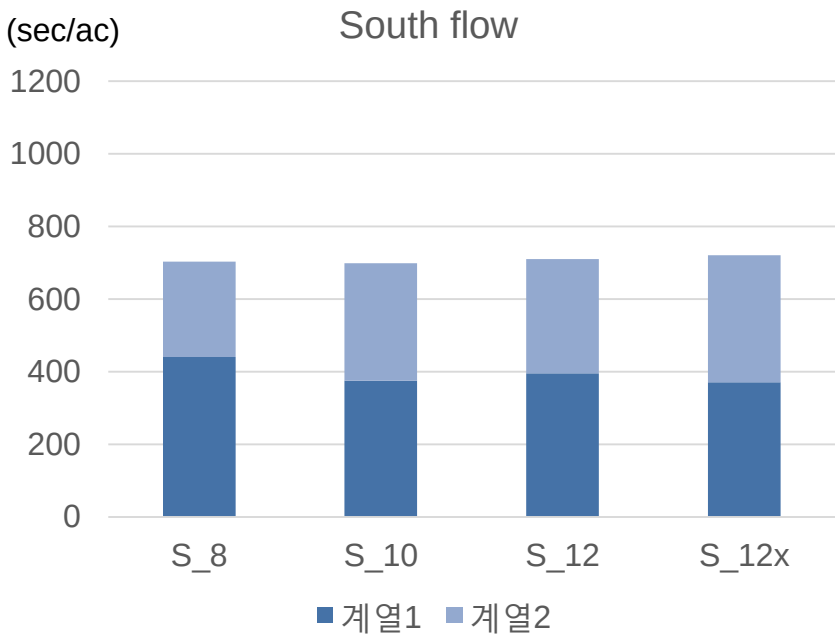
Dep No	24 | 18	20 | 21	28 | 21	28 | 21

Taxi-Out Time

- Mean taxi-out times by metering value
  - No significant impact by metering value
  - Affected by other factors such as run duration, runway changes, and TMI constraints



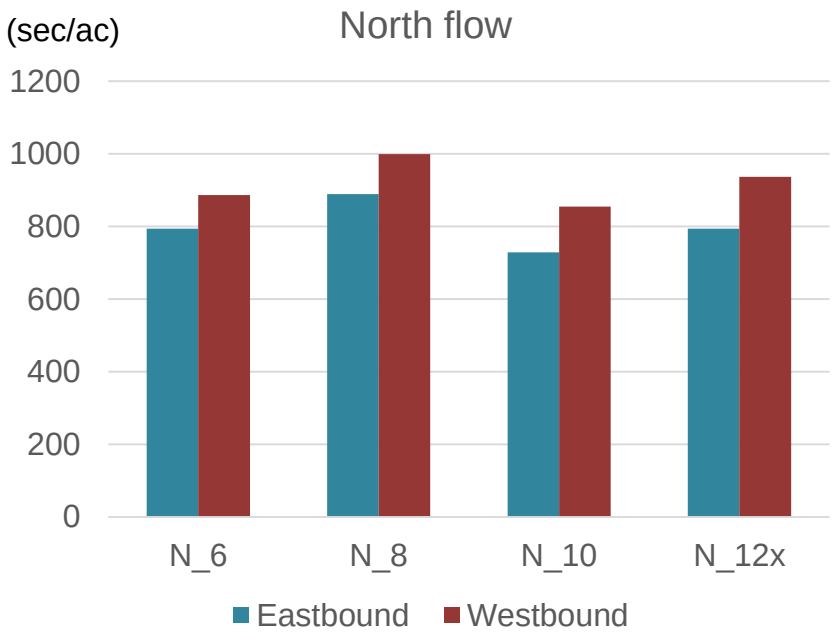
Dep No	35	44	27	54
Runway Change	9	9	4	12



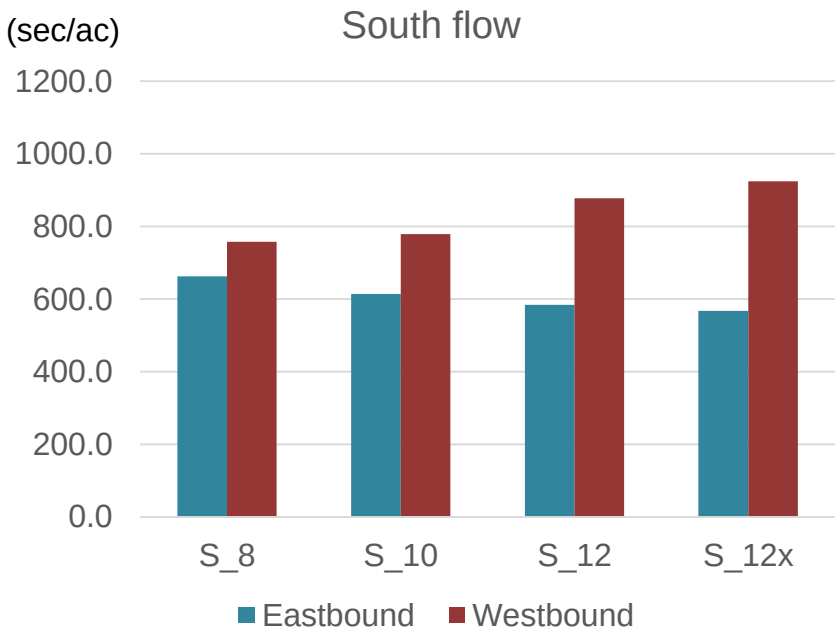
Dep No	42	41	49	49
Runway Change	8	7	8	11

Taxi-Out Time by Runway

- Mean taxi-out times by runway
  - Longer taxi distance for Westbound flights



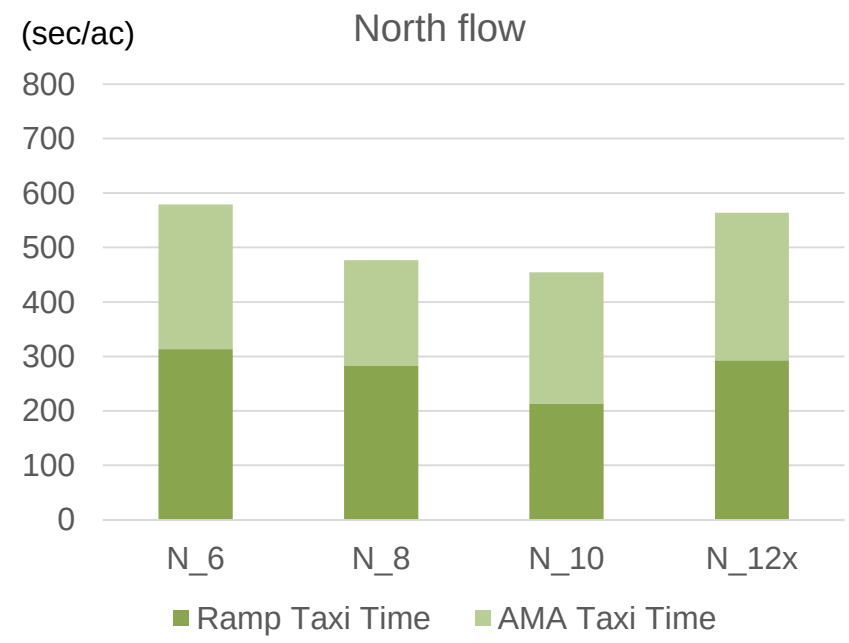
Dep No	15 | 20	17 | 27	14 | 13	20 | 34



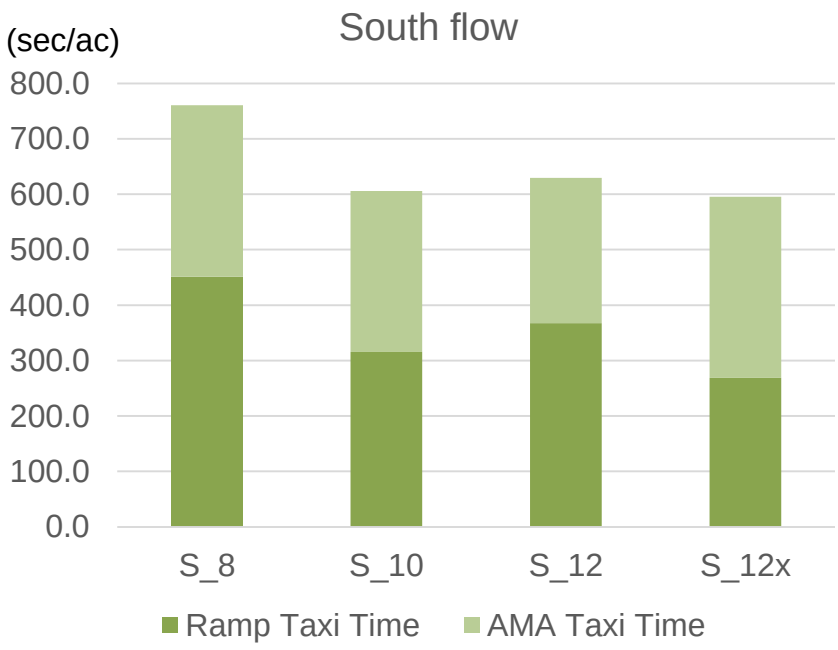
Dep No	24 | 18	20 | 21	28 | 21	28 | 21

Taxi-In Time

- Mean taxi-in times by metering value
  - All arrivals that reached gates
  - More holding at gate can increase taxi-in times due to gate conflicts.



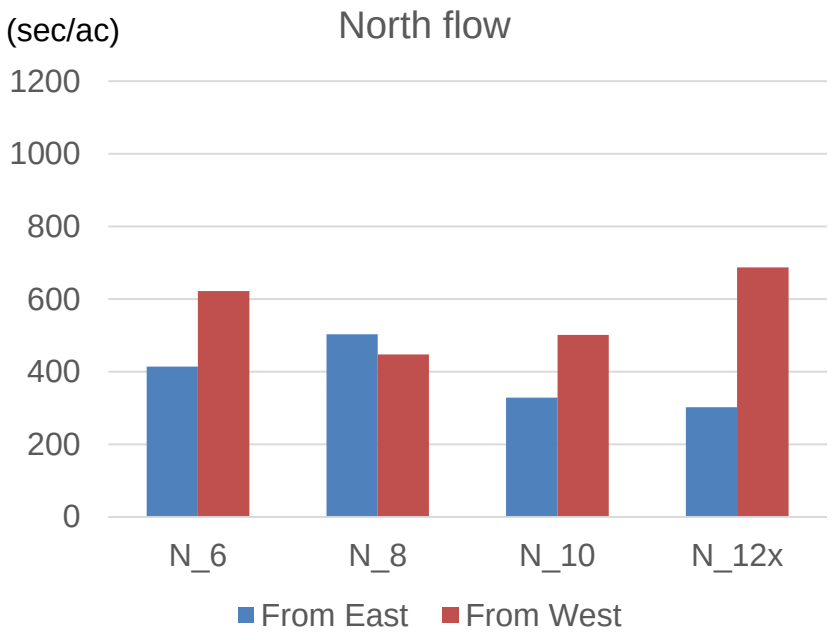
Arr No	34	38	26	50



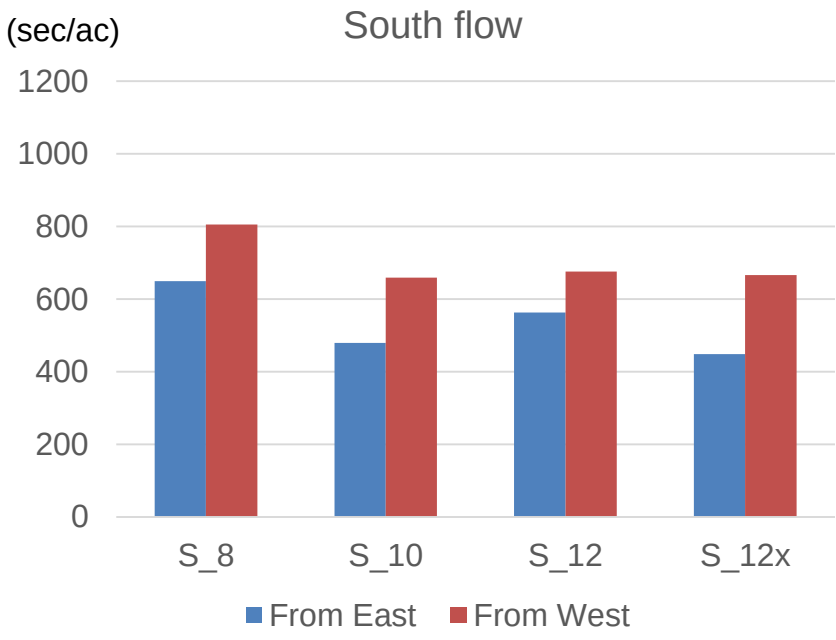
Arr No	28	34	39	43

Taxi-In Time by Runway

- Mean taxi-in times by runway
  - Affected by other factors such as run duration, runway changes, and interaction with departures



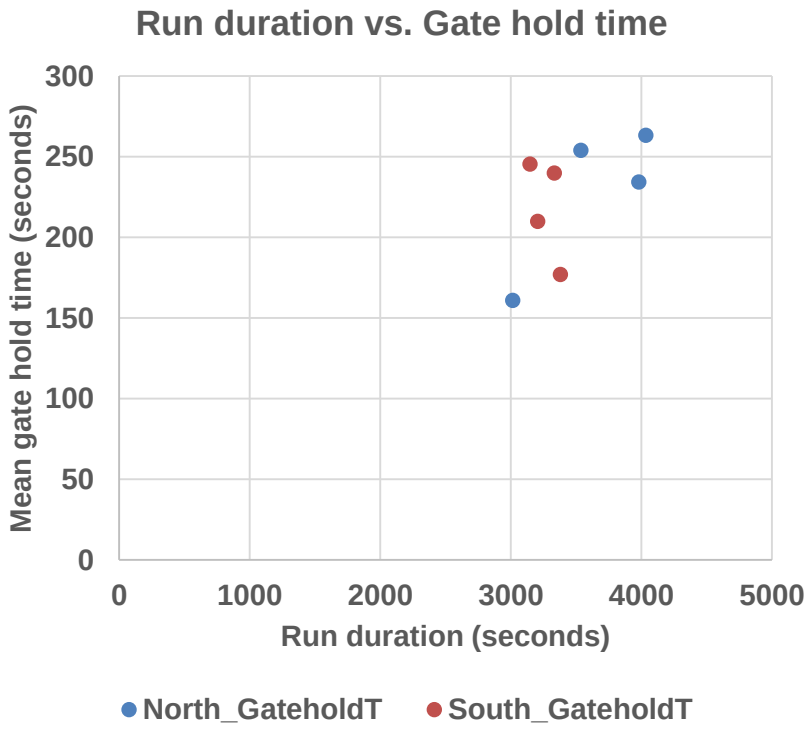
Arr No	7 | 27	20 | 18	7 | 19	16 | 34

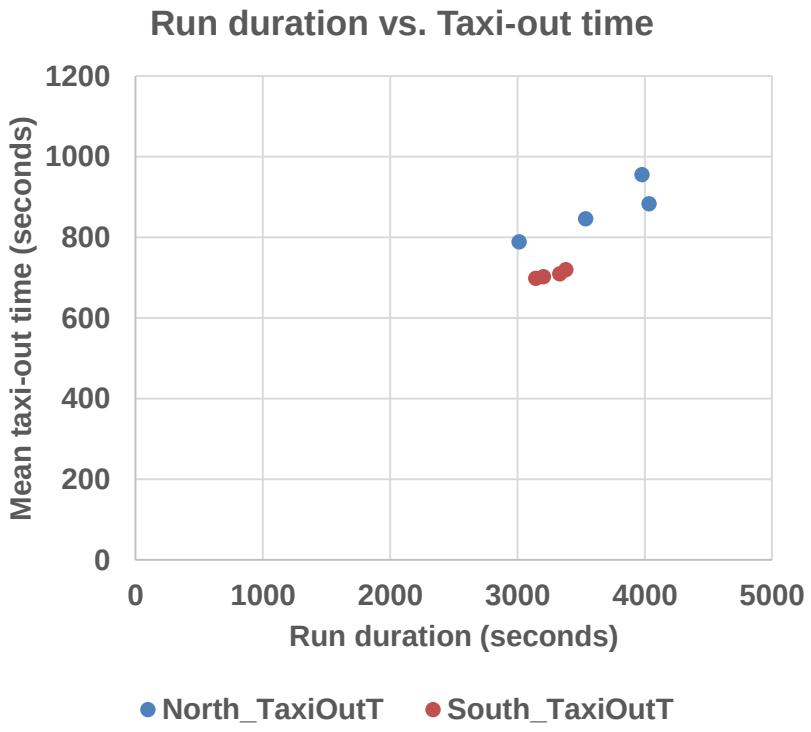


Arr No	8 | 20	10 | 24	16 | 23	14 | 29

Effects of Run Durations

- Mean values of gate hold times and taxi-out times look proportional to run durations.





Departure Runway Changes

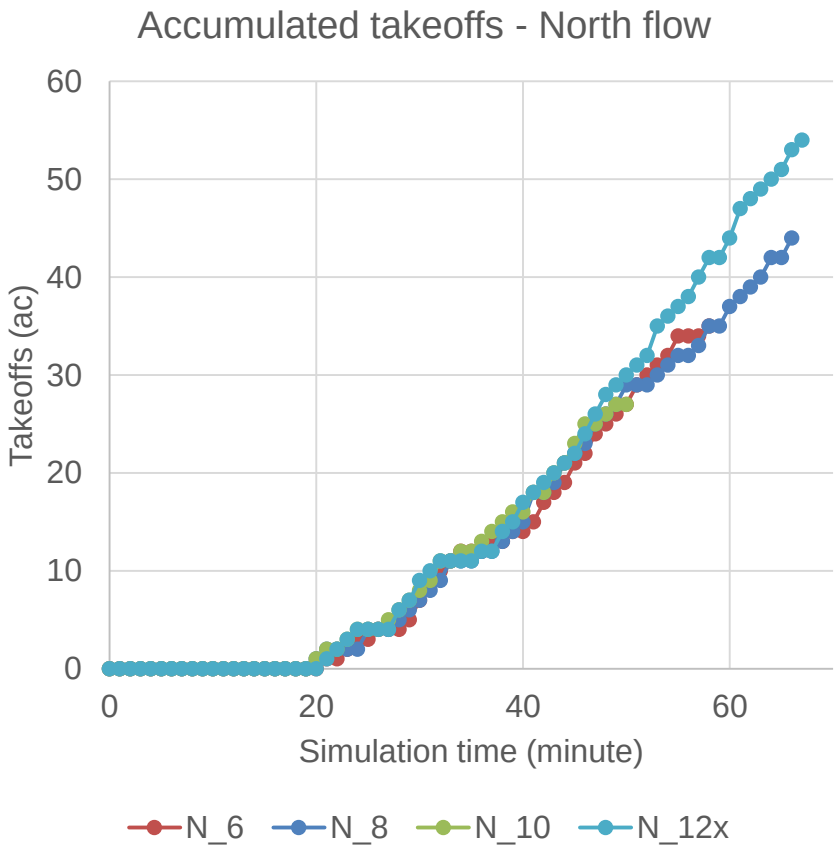
- Runway changes from schedule to actual assignment can impact the airport performance.

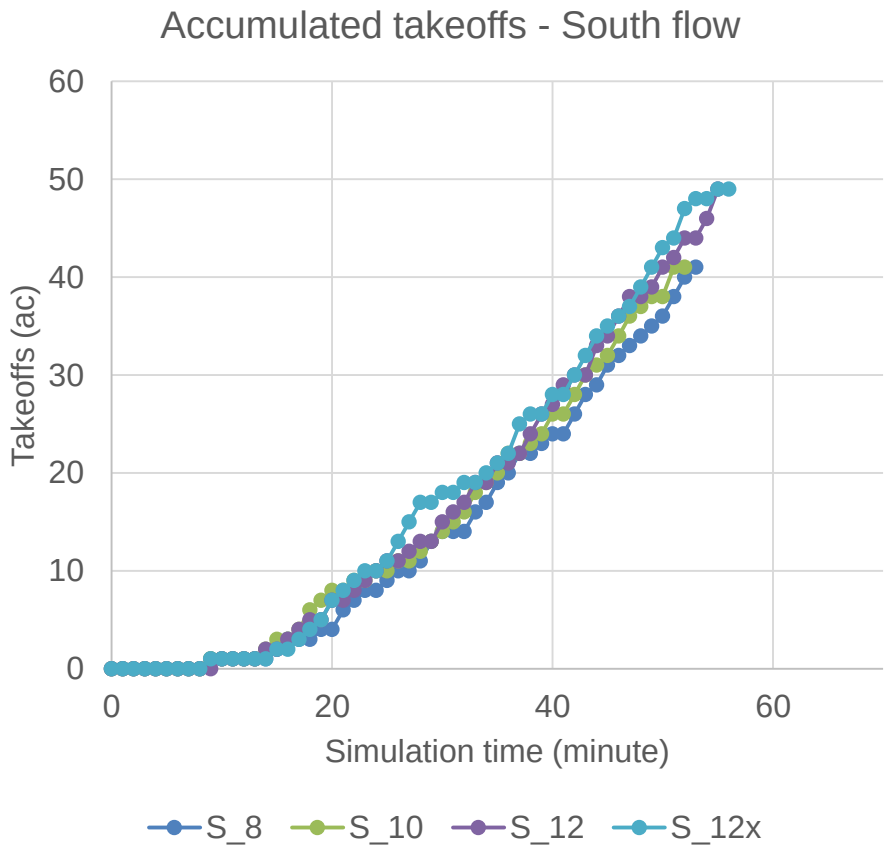
North flow	N_6	N_8	N_10	N_12x
36R (Eastbd)	33 -> 24	33 -> 24	33 -> 29	33 -> 27
36C (Westbd)	35 -> 44	35 -> 44	35 -> 39	35 -> 41
36R -> 36C	9	9	4	9
36C -> 36R	0	0	0	3
Total	9	9	4	12

South flow	S_8	S_10	S_12	S_12x
18L (Eastbd)	41 -> 39	41 -> 36	41 -> 39	41 -> 34
18C (Westbd)	22 -> 24	22 -> 27	22 -> 24	22 -> 29
18L -> 18C	5	6	5	9
18C -> 18L	3	1	3	2
Total	8	7	8	11

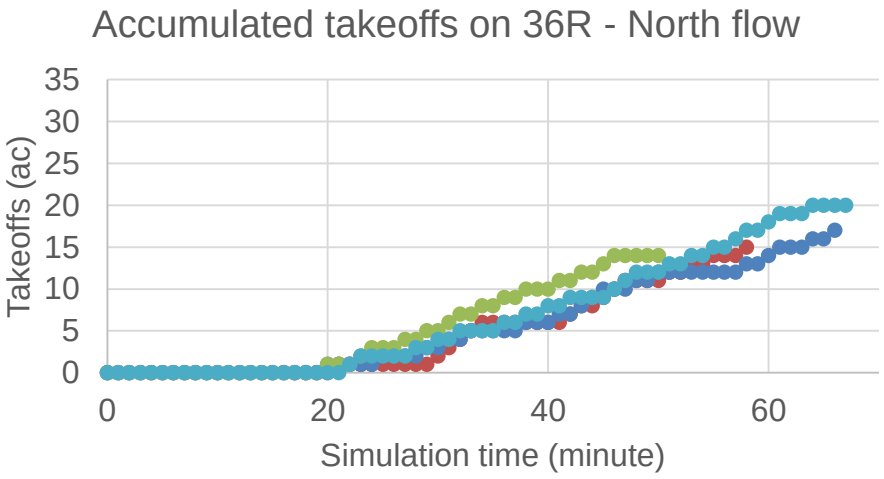
Departure Runway Throughput

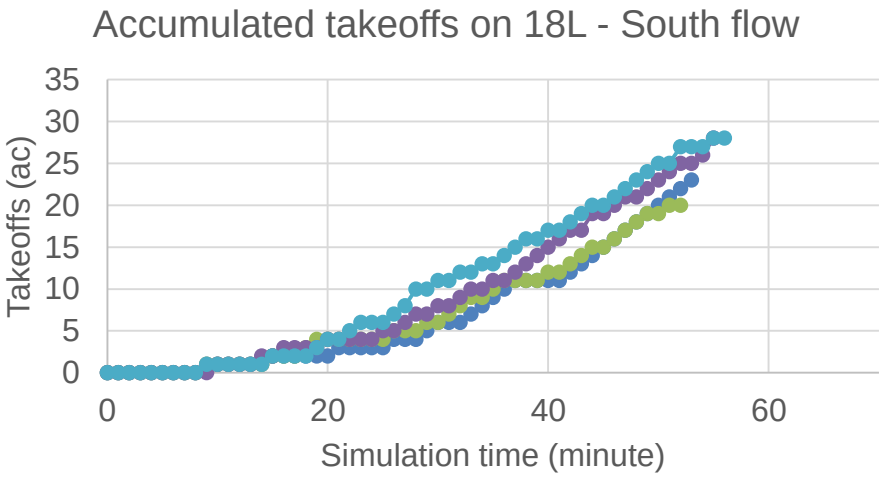
- Accumulated takeoffs
  - Similar takeoff rates, except for No MIT cases

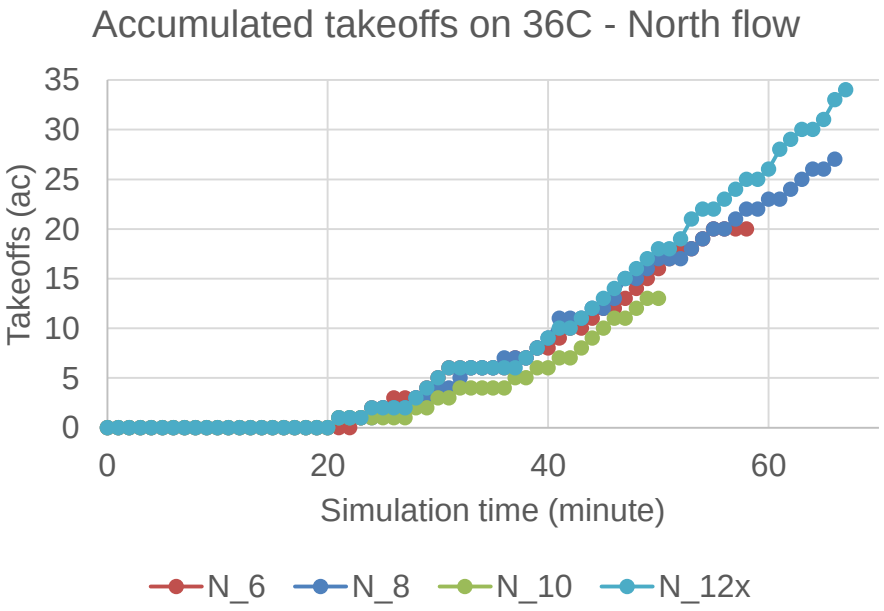


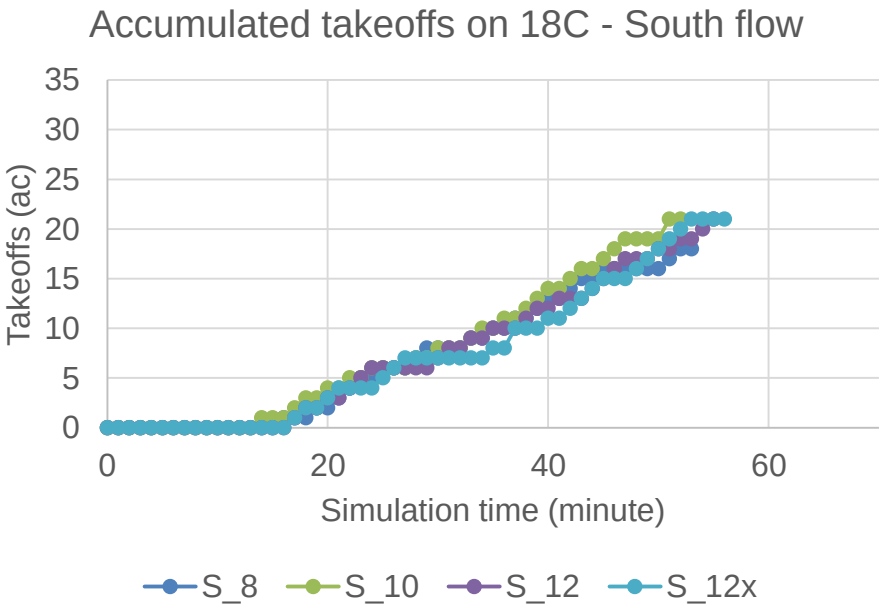


Runway Throughput by Runway

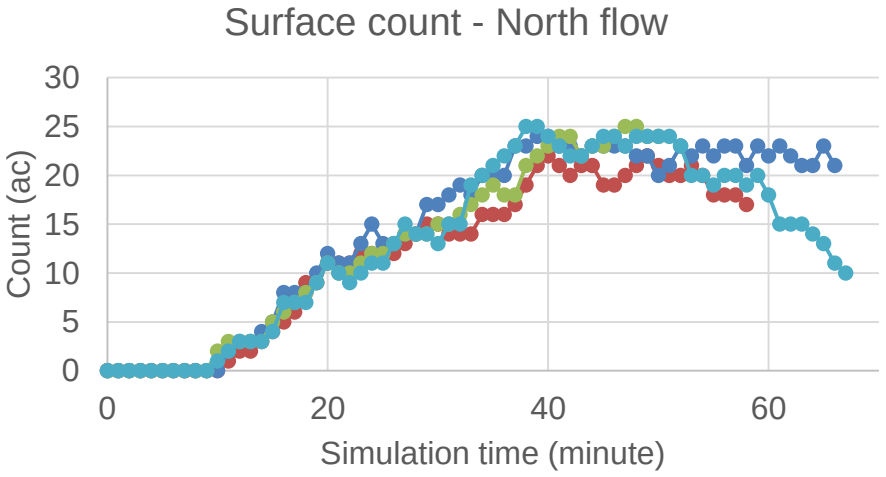


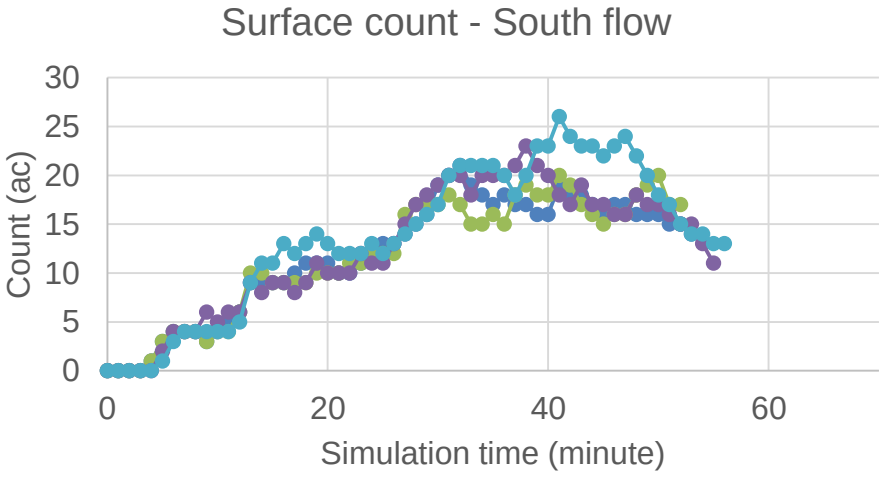


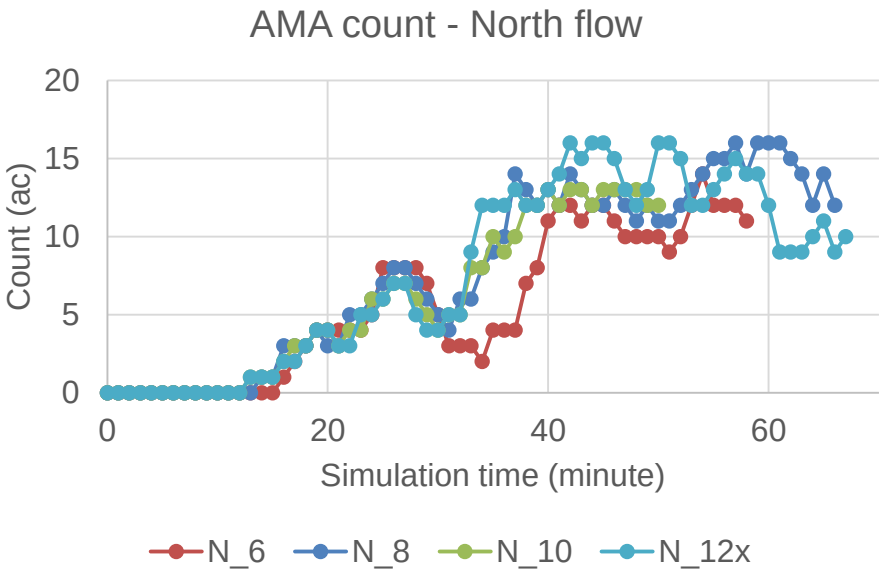


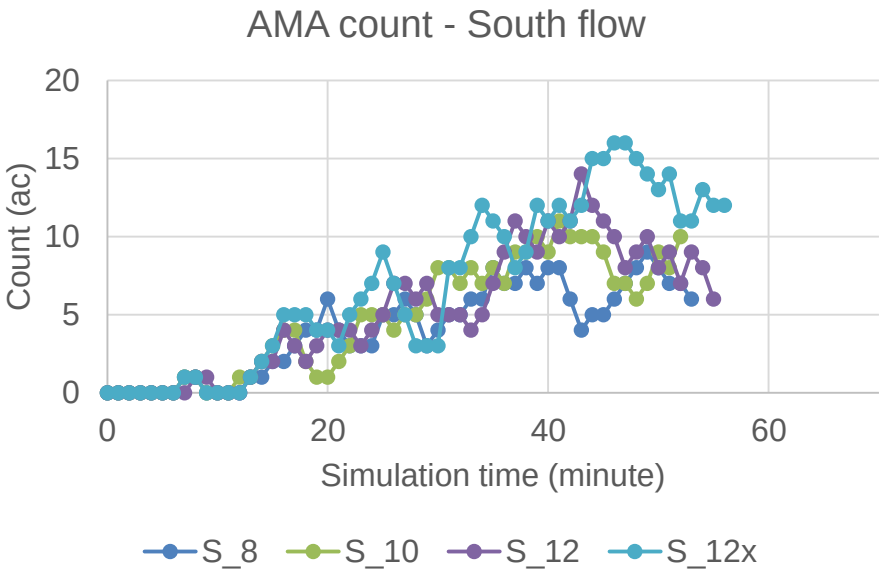


Queue Size from Gate/Spot to Runway

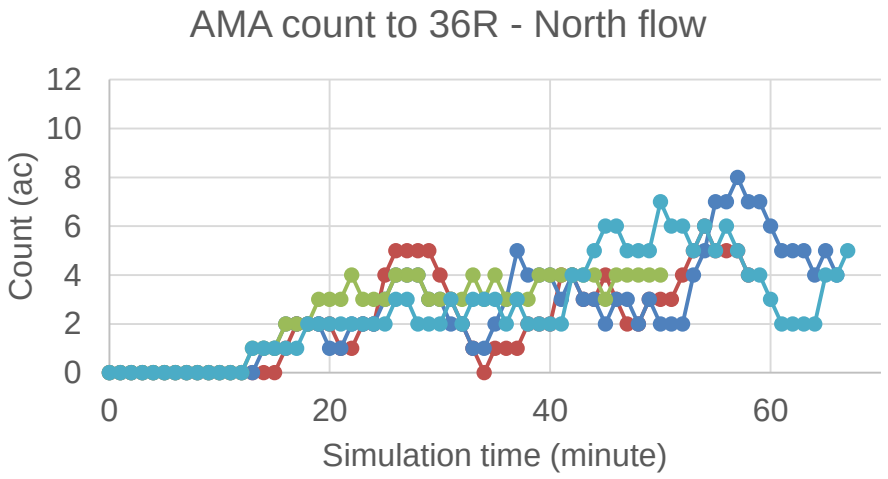


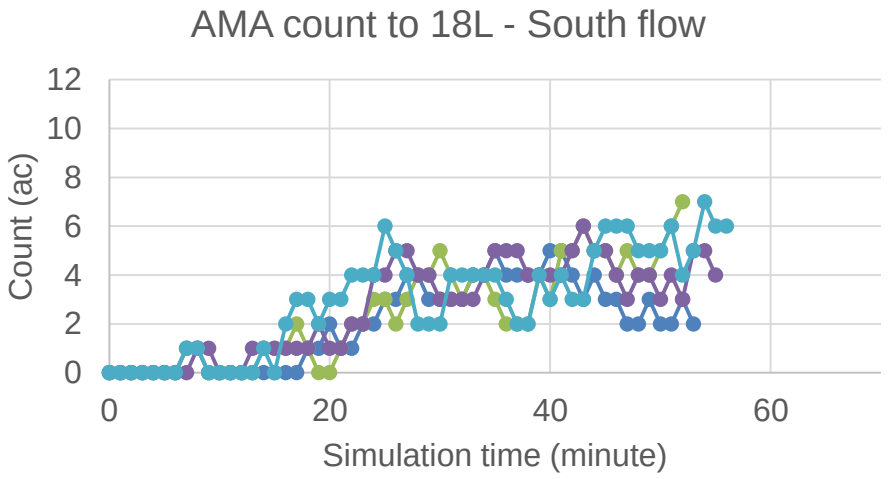


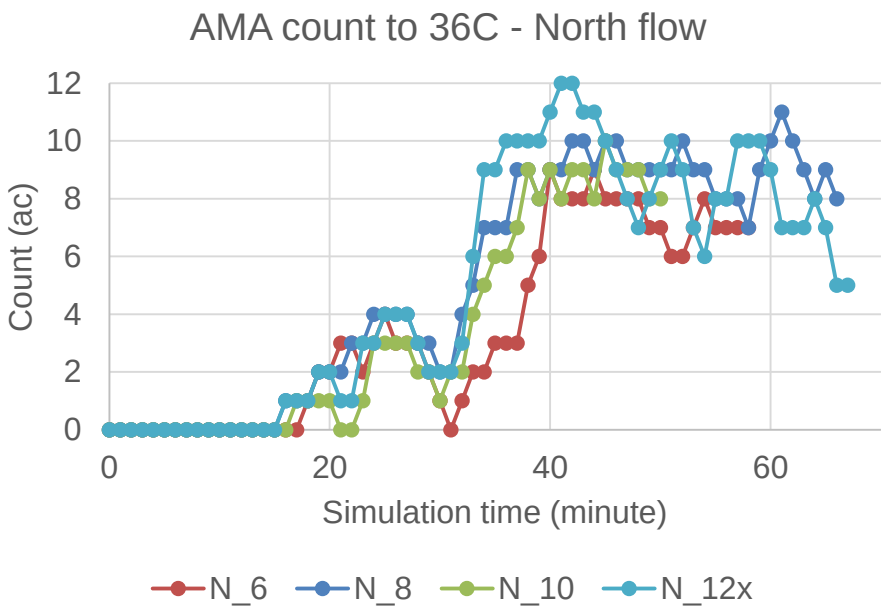


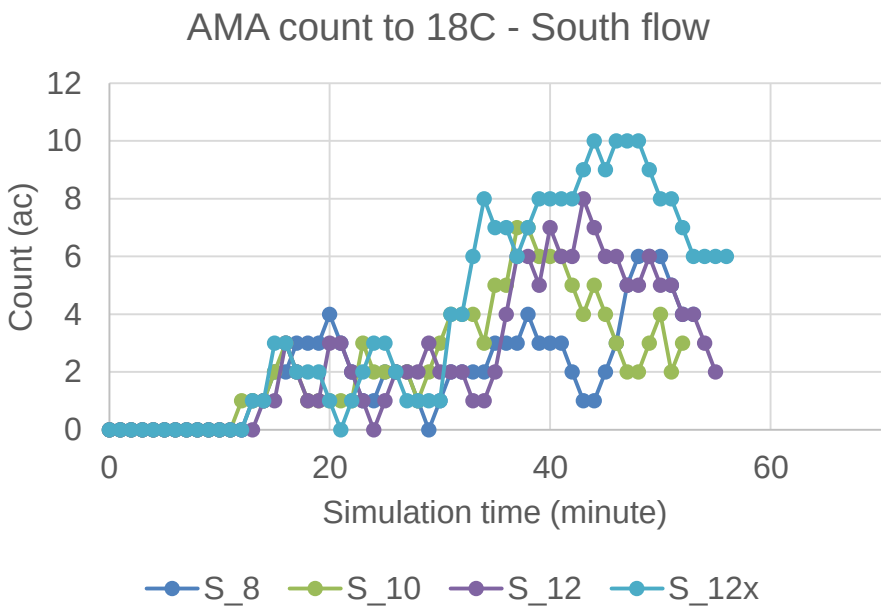


Queue Size by Runway



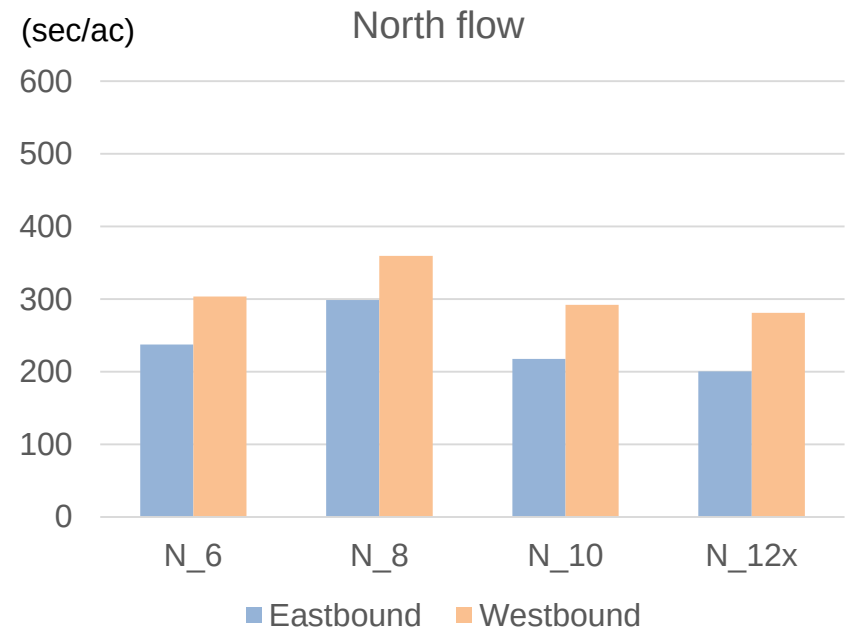




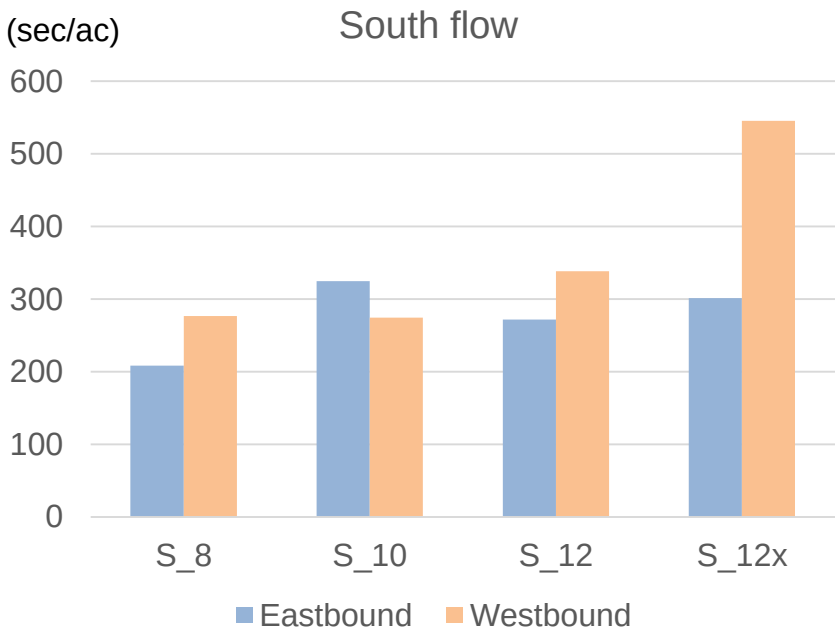


Time Spent in Departure Queue

- Mean queue time per aircraft by runway
  - (Sum of waiting times in queue during simulation run) / (Number of departures taken off)
  - Expected longer queue time with the higher metering value



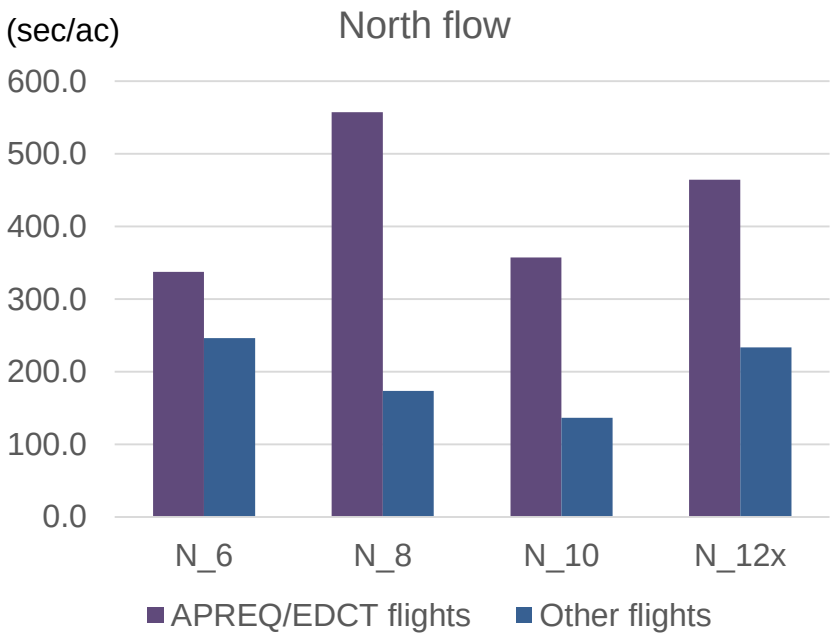
Dep No	15 | 20	17 | 27	14 | 13	20 | 34



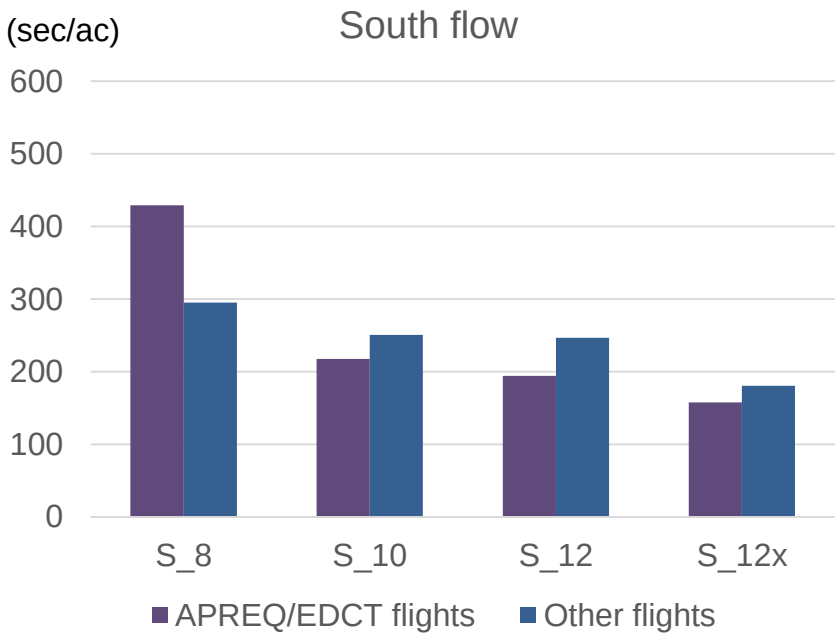
Dep No	24 | 18	20 | 21	28 | 21	28 | 21

APREQ/EDCT Flights vs. Other Flights

- Mean gate hold time comparison
  - TMI flights try to meet Controlled Takeoff Time (CTOT), whereas other flights follow pushback advisories (TTOT).
  - Different number of TMI flights for each run can affect.



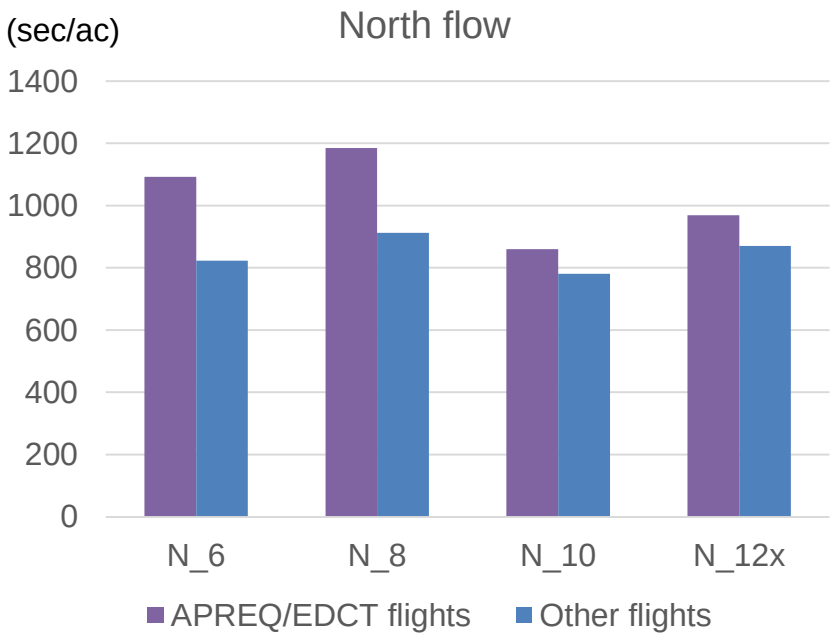
Dep No	3 | 32	7 | 37	3 | 24	7 | 47



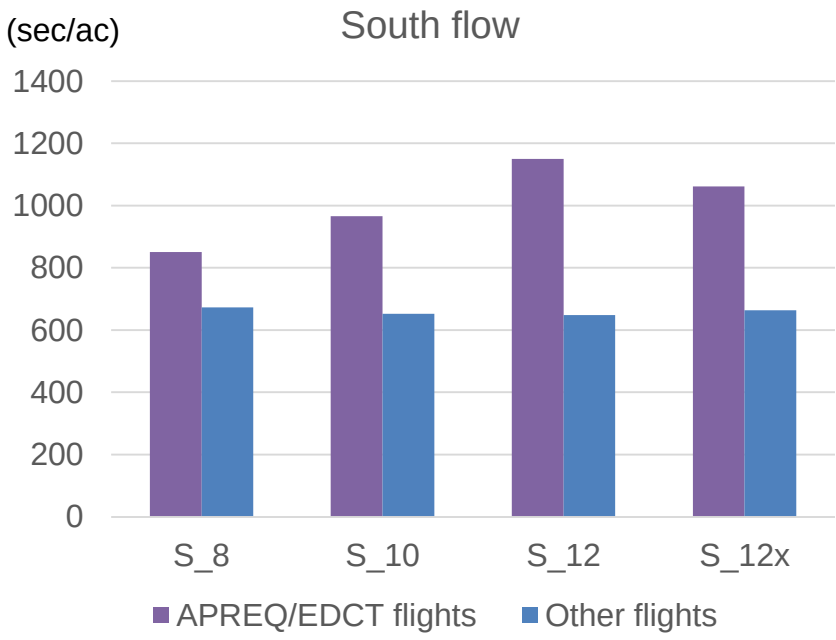
Dep No	7 | 35	6 | 35	6 | 43	7 | 42

APREQ/EDCT Flights vs. Other Flights

- Mean taxi-out time comparison
  - Longer taxi time for TMI flights, compared to other flights
  - For South flow, longer taxi time for TMI flights along with the higher metering value (less hold, longer queue)



Dep No	3 | 32	7 | 37	3 | 24	7 | 47



Dep No	7 | 35	6 | 35	6 | 43	7 | 42

Summary

- A HITL simulation was conducted to evaluate a tactical surface metering tool for ramp controllers at CLT.
- As the metering value increases, less gate holding and longer taxi times in departure queues were expected, but the simulation results might be affected by other factors:
  - Runway changes
  - Run duration
  - TMI flights
- APREQ/EDCT flights tends to have longer taxi times to meet the given takeoff times.